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(54) Title: PROCESSES AND SYSTEMS FOR LASER CRYSTALLIZATION PROCESSING OF FILM REGIONS ON A SUB-
STRATE UTILIZING A LINE-TYPE BEAM, AND STRUCTURES OF SUCH FILM REGIONS
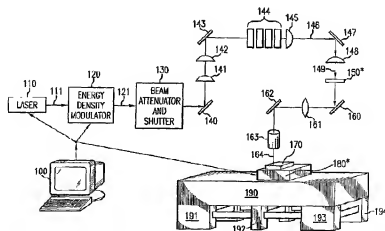
(57) Abstract: Process and system for processing a thin film sample, as well as at least one portion of the thin film structure are
provided. Irradiation beam pulses can be shaped to define at least one line-type beam pulse, which includes a leading portion, a top
portion and a trailing portion, in which at least one part has an intensity sufficient to at least partially melt a film sample. Irradiating
a first portion of the film sample to at least partially melt the first portion, and allowing the first portion to resolidify and crystallize to
form an approximately uniform area therein. After the irradiation of the first portion of the film sample, irradiating a second portion
using a second one of the line-type beam pulses to at least partially melt the second portion, and allowing the second portion to
resolidify and crystallize to form an approximately uniform area therein.. A section of the first portion impacted by the top portion
of the first one of the line-type beam pulses is prevented from being irradiated by trailing portion of the second one of the line-type
beam pulses.

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**PROCESSES AND SYSTEMS FOR LASER CRYSTALLIZATION PROCESSING
OF FILM REGIONS ON A SUBSTRATE UTILIZING A LINE-TYPE BEAM,
AND STRUCTURES OF SUCH FILM REGIONS**

5   SPECIFICATION

FIELD OF THE INVENTION

The present invention relates to techniques for processing of films, and
more particularly to location-controlled techniques for processing semiconductor films
using a line-type beam so as to obtain a substantial uniformity of certain regions of the
10   thin films in which microstructures (e.g., thin-film transistor "TFT" devices) can be
situated.

BACKGROUND OF THE INVENTION

Semiconductor films, such as silicon films, are known to be used for
providing pixels for liquid crystal display devices. Certain prior art systems utilize line-
15   type beams which are shaped to have a particular line-shape. An exemplary illustration
of the line-type beam pulse 200, and a profile thereof are illustrated in Fig. 4A. In
particular, the line beam pulse 200 may defined by a length L and width W'. The profile
of the line-type beam pulse 200 illustrated in Fig. 4A has a convex top portion 205, a
large section of which has sufficient energy density to be below a complete melting
20   energy density threshold. This profile of the line-type beam pulse 200 also has a leading
portion 210 and a trailing portion 215. The leading portion 210 has an energy density
beginning from a low or negligible energy density level, continuing to reach a
crystallization threshold, and ending below the complete melting energy density
threshold so as to reach the convex top portion 205. The trailing edge portion 215 has an
25   energy density starting from the edge of the convex top portion 205 (which is at a
sufficient energy below the complete melting energy density threshold), passing the
crystallization threshold, and ending at the low or negligible energy density level. The
length L of the line beam can be between 10 cm and 50 cm so as to irradiate a significant

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section of a thin film provided on a sample. The conventional system generally use line
beam pulses to irradiate the same section of the sample over 10 times with the energy
density which is somewhat below the complete melting threshold. In this manner, a more
uniform film may be attained, but the processing of such film is extremely slow. Indeed,
5   the systems which use such line-type beam 200 are currently not suitable for quick
processing of samples. In addition, when the edge portions (i.e., the leading and trailing
edge portions 210, 215) irradiate the corresponding sections of the thin film, non-
uniformity may be created in these sections.

          As shown in Fig. 4B, other conventional systems attempt to overcome
10   these problems associated with non-uniformity by continuously scanning display areas
220, 225 of the sample 180, until the entire area is completely irradiated. As shown in
Fig. 5, this is generally performed by irradiating areas of the sample using successive
pulses of the line-type beam 200, such that a significant portion of the area irradiated by a
first pulse 300 of the beam 200 is subsequently irradiated by the next pulse 310. It
15   follows that a sizable portion of the area of the sample irradiated by the pulse 310 is
reirradiated by the subsequent pulse 320. Also, a large portion of the area irradiated by
the pulse 320 is reirradiated by the next pulse 330, and so on. The overlap of the areas
irradiated by the adjacent pulses is provided such that the distance between the adjacent
pulses is the width of the top portion of the pulse divided by between 10 and 100, and
20   preferably divided by approximately 20.

          It may be possible to reduce the non-uniformity of the irradiated sections
of the thin film sample by maintaining the energy density of the line-type beam pulse 200
to be above the complete melting threshold. In particular, as shown in Figures 6A and
6B, sections of a thin film sample irradiated at an energy density above the complete
25   melting threshold 250 form small polycrystalline grains compared to sections of the thin
film sample irradiated at an energy density below the complete melting threshold.
Between these sections, there is a narrow region where grains are very large, due to near-
complete melting of the film. In addition, when the energy density is below the
crystallization threshold, the irradiated area is amorphous.

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It is conceivable to reduce the non-uniformity of the irradiated sections of the thin film sample by maintaining the energy density of the line-type beam pulse 200 to be below the complete melting threshold. In particular, as shown in Figures 6C and 6D, sections of a thin film sample irradiated with beam pulses 200 at a constant energy density that is above the crystallization threshold and below the complete melting threshold 205' have an approximately uniform grain size.

However, there are disadvantages to the use of these conventional methods. For example, when the irradiated areas of the thin film are required to be overlapped, the processing time of the entire sample is slow. This is because the sample is processed to ensure the reirradiation of significant parts of the previously irradiated areas of the thin film.

SUMMARY OF THE INVENTION

One of the objects of the present invention is to provide an improved process and system which irradiate at least one thin film section of the substrate using a line-type beam pulses so as to at least partially melt these sections, and without the irradiated areas being re-irradiated by the following beam pulses. In this manner, the melted sections of the thin film sections resolidify to form substantially uniform crystallized regions therein. Due to the uniformity of these regions of the resolidified thin film sections, it is possible to place the TFT devices in such regions. Thus, the TFT devices situated in such manner would likely have at least similar performance with respect to one another. Another object of the present invention is to continuously translate and irradiate one or more sections of the thin film sample (e.g., without stopping) such that the above-described uniformity is achieved in an accelerated manner.

In one exemplary embodiment of the present invention, a process and system for processing a semiconductor thin film sample, as well as at least one portion of the semiconductor thin film structure are provided. In particular, a beam generator can be controlled to emit successive irradiation beam pulses at a predetermined repetition rate. Each of the irradiation beam pulses can be shaped to define at least one line-type beam

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pulse, with the line-type beam pulses being provided for impinging the film sample. These line-type beam pulses can include at least one part which have an intensity sufficient to at least partially melt irradiated portions of the film sample. Thereafter, a first portion of the film sample is irradiated using a first one of the line-type beam pulses

5   to at least partially melt the first portion, with the irradiated first portion being allowed to resolidify and crystallize. After the irradiation of the first portion of the film sample, a second portion of the film sample is irradiated using a second one of the line-type beam pulses to at least partially melt the second portion, with the irradiated second portion also being allowed to resolidify and crystallize. An emission of the second one of the line-

10 type beam pulses may immediately follow an emission of the first one of the line-type beam pulses. A profile of each of the line-type beam pulses may includes a leading portion, a top portion and a trailing portion. For example, a section of the first portion impacted by the top portion of the first one of the line-type beam pulses may be prevented from being irradiated by trailing portion of the second one of the line-type

15 beam pulses.

        In another exemplary embodiment of the present invention, the first portion of the film sample is irradiated by the top portion of the first one of the line-type beam pulses, wherein the second portion of the film sample is irradiated by the top portion of the second one of the line-type beam pulses. The top portion of each of the

20 line-type beam pulses may have energy density which is above a complete melting threshold Each of the leading and trailing portions of the first one of the line-type beam pulses can irradiate a part of the first portion, and each of the leading and trailing portions of the second one of the line-type beam pulses can irradiate a part of the second portion. In addition, each of leading and trailing portions of the first and second ones of the line-

25 type beam pulses may include first and second sections. Each of the first sections of the leading and trailing portions of the first and second ones of the line-type beam pulses may include an energy density which is sufficient to at least partially melt the respective first portion and/or the respective second portion. Also, each of the second sections of the leading and trailing portions of the first and second ones of the line-type beam pulses

can have an energy density lower than a threshold level which is sufficient to at least
partially melt the part of one of the respective first portion and the respective second
portion. The second portion can be irradiated after the irradiation of the first portion and
after the film sample is translated for a particular distance with respect to an impingement
by the beam pulses of the first portion. The first section of the leading portion of the first
one of the line-type beam pulses may have a first length, and the first section of the
trailing portion of the second one of the line-type beam pulses can have a second length.
The top portion may have a third length. The particular distance can be greater than the
sum of the third length and of the larger one of the first and second lengths.

According to still another embodiment of the present invention, data
associated with locations on the film sample to be irradiated is received. Then, after the
irradiation of the first portion and before the irradiation of the second portion, the film
sample is translated for a particular distance with respect to an impingement by the beam
pulses based on such received data. The irradiation beam pulses can be shaped by a mask
to define the line-type beam pulses. In addition, the first and second ones of the line-type
beam pulses can at least partially melt the respective first and second portions of the film
sample. Furthermore, the film sample can be translated for the particular distance with
respect to an impingement by the beam pulses in a periodic manner and also based on an
irradiation frequency of the irradiation beam generator. Also, the first and second
portions of the film sample can include pixel areas. In addition, the first and second
portions can include areas, which are configured to situate thereon an active region of at
least one thin-film transistor "TFT" device.

The accompanying drawings, which are incorporated and constitute part of
this disclosure, illustrate a preferred embodiment of the invention and serve to explain the
principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a schematic block diagram of an exemplary embodiment of an
irradiation system according to the present invention which allows selected areas of a

semiconductor thin film to be continuously scanned, at least partially melted and without re-irradiating these areas, in a predetermined controlled manner using a line-type beam;

Fig. 1B is an enlarged cross-sectional side view of the sample which includes the semiconductor thin film;

Fig. 2 is a top view of an exemplary embodiment of a mask according to the present invention utilized by the system illustrated Fig. 1A, which patterns a beam so as to have a line-type shape for irradiating the selected areas of the semiconductor thin film;

Fig. 3 is an exemplary illustration of a continuous-motion irradiation of the entire semiconductor thin film using the system of Fig. 1A and the mask of Fig. 2;

Fig. 4A is a cross-sectional profile of the line-type beam which can be shaped by optics of the system of Fig. 1A and/or patterned by the mask of Fig. 2, and may be used for irradiating the semiconductor thin film according to a first exemplary embodiment of the present invention which has energy density above the complete melting threshold;

Fig. 4B is an illustration of a continuous scan processing of the semiconductor thin film using conventional systems, which re-irradiate previously irradiated areas or apply beams whose energy density is below a complete melting threshold;

Fig. 4C is a cross-sectional profile of the line-type beam according to a second exemplary embodiment of the present invention which has energy density above the crystallization threshold and below the complete melting threshold;

Fig. 5 is an illustration of profiles of multiple line-type beams which re-irradiate previously irradiated portions of the semiconductor thin film;

Figs. 6A and 6B are examples of the results of irradiations of the conventional systems and methods when utilizing line-type beams whose energy densities are above the complete melting threshold;

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Figs. 6C and 6D are examples of the results of irradiations of the conventional systems and methods when utilizing line-type beams whose energy densities are between the crystallization threshold and the complete melting threshold;

Fig. 7 is an exemplary illustration of sequential movements of the semiconductor film of a sample with respect to the pulses of the line-type beam shaped by the optics of the system of Fig. 1A or patterned by the mask of Fig. 2 according to an exemplary embodiment of the present invention;

Fig. 8 is a cross-sectional profile of another exemplary line-type beam which can be shaped by optics of the system of Fig. 1A and/or patterned by the mask of Fig. 2, and which has either minimal or insignificant sloping edge portions;

Fig. 9A is an illustration of the two particular areas irradiated, re-solidified and crystallized areas corresponding to the areas of Fig. 7 in which the entire TFT device is situated on the small uniformed grained region formed through complete melting and re-solidification according to the present invention;

Fig. 9B is an illustration of the two particular areas irradiated, re-solidified and crystallized areas corresponding to the areas of Fig. 7 in which only the entire cross-section of the active region of the TFT device is situated in the small uniformed grained region formed through nucleation, while other regions are provided over border areas between the crystallized areas;

Fig. 10 is another exemplary illustration of sequential movements of the semiconductor film of the sample with respect to the pulses of the line-type beam shaped by the optics of the system of Fig. 1A or patterned by the mask of Fig. 2 according to another exemplary embodiment of the present invention, in which the entire sample is irradiated in two passes; and

Fig. 11 is a flow diagram representing an exemplary processing procedure of the present invention under at least partial control of a computing arrangement of Fig. 1A using the exemplary techniques of the present invention of Figs. 7 and 10.

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DETAILED DESCRIPTION

It should be understood that various systems and methods according to the present invention can be utilized to at least partially melt, then solidify and crystallize one or more areas on a semiconductor thin film (e.g., silicon) using line-type beam pulses,
5   while continuously translating the sample and without re-irradiating the previously irradiated and resolidified areas to generate substantially uniform regions on the thin film. The exemplary embodiments of the systems and process to generate such areas, as well as of the resulting crystallized semiconductor thin films shall be described in further detail below. However, it should be understood that the present invention is in no way
10 limited to the exemplary embodiments of the systems, processes and semiconductor thin films described herein.

Certain systems for providing a continuous motion SLS are described in U.S. Patent Application Serial No. 09/526,585 (the "'585 application"), the entire disclosure of which is incorporated herein by reference. Substantially similar systems
15 according to the exemplary embodiment of the present invention can be employed to generate at least partially irradiated, solidified and crystallized portions of the semiconductor film described above in which it is possible to process the entire semiconductor thin film in a controlled and accelerated manner with a line-type beam. In particular, the system according to the present invention can be used on a sample 170
20 which has an amorphous thin film (e.g., silicon) thereon that is irradiated by irradiation beam pulses to promote the melting, subsequent solidification and crystallization of the particular areas of the semiconductor thin film. As shown in Fig. 1A, the exemplary system includes a beam source 110 (e.g., a Lambda Physik model LPX-315I XeCl pulsed excimer laser) emitting an irradiation beam (e.g., a laser beam), a controllable
25 beam energy density modulator 120 for modifying the energy density of the laser beam, a MicroLas two plate variable attenuator 130 (e.g., a device by MicroLas), beam steering mirrors 140, 143, 147, 160 and 162, beam expanding and collimating lenses 141 and 142, a beam homogenizer 144, a condenser lens 145, a field lens 148, a projection mask 150 which may be mounted in a translating stage (not shown), an eye piece 161, a

controllable shutter 152, a multi-element objective lens 163 for focusing a radiation beam
pulse 164 onto the sample 170 having the semiconductor thin film to be processed
mounted on a sample translation stage 180, a granite block optical bench 190 supported
on a vibration isolation and self-leveling system 191, 192, 193 and 194, and a computing
5   arrangement 100 (e.g., a general purpose computer executing a computer program
according to the present invention or a special-purpose computer) coupled to control the
beam source 110, the beam energy density modulator 120, the variable attenuator 130,
the shutter 152 and the sample translation stage 180.

        The sample translation stage 180 is preferably controlled by the computing
10   arrangement 100 to effectuate translations of the sample 170 in the planar X-Y directions,
as well as in the Z direction. In this manner, the computing arrangement 100 controls the
relative position of the sample 170 with respect to the irradiation beam pulse 164. The
repetition and the energy density of the irradiation beam pulse 164 are also controlled by
the computing arrangement 100. It should be understood by those skilled in the art that
15   instead of the beam source 110 (e.g., the pulsed excimer laser), the irradiation beam pulse
can be generated by another known source of short energy pulses suitable for at least
partially melting (and possibly fully melting throughout their entire thickness) selected
areas of the semiconductor (e.g., silicon) thin film of the sample 170 in the manner
described herein below. Such known source can be a pulsed solid state laser, a chopped
20   continuous wave laser, a pulsed electron beam and a pulsed ion beam, etc. Typically, the
radiation beam pulses generated by the beam source 110 provide a beam intensity in the
range of 10 mJ/cm^2 to 1 J/cm^2, a pulse duration (FWHM) in the range of 10 to 300 nsec,
and a pulse repetition rate in the range of 10 Hz to 300 Hz.

        While the computing arrangement 100, in the exemplary embodiment of
25   the system shown in Fig. 1A, controls translations of the sample 170 via the sample stage
180 for carrying out the processing of the semiconductor thin film of the sample 170
according to the present invention, the computing arrangement 100 may also be adapted
to control the translations of the mask 150 and/or the beam source 110 mounted in an
appropriate mask/laser beam translation stage (not shown for the simplicity of the

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depiction) to shift the intensity pattern of the irradiation beam pulses 164, with respect to the semiconductor thin film of the sample 170, along a controlled beam path. Another possible way to shift the intensity pattern of the irradiation beam pulse is to have the computing arrangement 100 control a beam steering mirror. The exemplary system of
5   Fig. 1A may be used to carry out the processing of the semiconductor thin film of the sample 170 in the manner described below in further detail. The mask 150 can be used by the exemplary system of the present invention to well define the profile of the resulting masked beam pulse 164, and to reduce the non-uniformity of the adjacent portions and edge regions of the portions of the semiconductor thin film when these
10   portions are irradiated by such masked beam pulse 164 and then crystallized.

As illustrated in Fig. 1B, a semiconductor thin film 175 of the sample 170 can be directly situated on, e.g., a glass substrate 172, and may be provided on one or more intermediate layers 177 there between. The semiconductor thin film 175 can have a thickness between 100Å and 10,000Å (1μm) so long as at least certain necessary areas
15   thereof can be at least partially or completely melted throughout their thickness. According to an exemplary embodiment of the present invention, the semiconductor thin film 175 (e.g., an amorphous silicon thin film) can be composed of silicon, germanium, silicon germanium (SeGe), etc. all of which preferably have low levels of impurities. It is also possible to utilize other elements or semiconductor materials for the semiconductor
20   thin film 175. The intermediary layer 177, which is situated immediately underneath the semiconductor thin film 175, can be composed of silicon oxide (SiO_2), silicon nitride (Si_3N_4), and/or mixtures of oxide, nitride or other materials that are suitable for promoting grain growth within the designated areas of the semiconductor thin film 175 of the sample 170. The temperature of the glass substrate 172 can be between room
25   temperature and 800°C. Higher temperatures of the glass substrate 172 can be accomplished by preheating the substrate 172 which would effectively allow larger grains to be grown in the irradiated, re-solidified, and then crystallized areas of the semiconductor thin film 175 of the sample 170 due to the proximity of the glass substrate 172 to the thin film 175.

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The semiconductor thin film 175 can be irradiated by the beam pulse 164 which can be shaped using the mask 150 according to an exemplary embodiment of the present invention as shown in Fig. 2. The exemplary mask 150 is sized such that its cross-sectional area is preferably larger than that of the cross-sectional area of the beam pulse 164. In this manner, the mask 150 can pattern the pulsed beam to have a shape and profile directed by one or more open or transparent regions of the mask 150. The exemplary embodiment of the mask 150 shown in Fig. 2 includes an open or transparent region 157 that has a substantially long and narrow shape. This shape is defined by an opaque or beam-blocking region 155. The open or transparent region 157 (which may have a length L and a width A) permit beam pulses to irradiate there-through to at least partially melt the areas of the semiconductor thin film 175 that they impinge. Each of the beam pulses shaped by the mask 175 has a shape substantially corresponding to the shape of the open or transparent region 157.

An example of such beam pulse 200 is shown in Fig. 4A, which illustrates a first exemplary profile of the beam pulse, along with particular dimensions of sections thereof, which can be shaped by the optics of the system illustrated in Fig. 1A and/or produced by the mask 150 of Fig. 2. In particular, the shaped-beam pulse 200 may have a particular width W' (e.g., 300 μm to 1.2 mm) and a particular length L' (e.g. 10 cm to 50 cm), both of which relating to the length L and the width W of the open/transparent region 157 of the mask 150. In this manner, the beam pulse 200 thus produced by, e.g., the mask 150 extends for the length L to preferably process the entire length of the thin film sample 175. The entire sample 170 can be irradiated by the beam pulses 200 of the beam 164 as shown in Fig. 3, and described in further detail below. The profile 220 of the beam pulse 200 includes a top portion 205, a leading edge portion 210 and a trailing edge portion 215, all of which can extend for a particular distance. The top portion 205 may extends for a distance A within which the energy density is at or above the complete melting threshold. This distance A can be between 200 μm to 1 mm. The leading edge portion 210 can extend for a distance B1 (e.g., between 50μm and 100 μm), and the trailing edge portion 215 may extend for a distance B2 (e.g., also between 50μm and 100

μm). The leading edge potion 210 has a section with a length of B1P, which extends from the point of the crystallization threshold to the point of the complete melting threshold, and which can be approximately half the size of the length B1. Similarly, the trailing edge potion 215 has a section with a length of B2P which extends from the point

5 of the crystallization threshold to the point of the complete melting threshold, and which can be approximately half the size of the length B2.

A second exemplary profile of the beam pulse 200 is illustrated in Fig. 4C, which can also be shaped by the optics of the system illustrated in Fig. 1A and/or produced by the mask 150 of Fig. 2. In this second exemplary embodiment, the energy

10 density of the beam pulse 200 has a profile 220' with an energy density that is below the complete melting threshold. In particular, this profile 220' includes a top portion 205', a leading edge portion 210' and a trailing edge portion 215'. The top portion 205' of this embodiment extends for a distance C, within which the energy density is approximately constant. The distance C may be between 200 μm to 1 mm. The leading edge portion

15 210' can extend for a distance D1 (e.g., between 50μm and 100 μm), and the trailing edge portion 215' may extend for a distance D2 (e.g., also between 50μm and 100 μm). The leading edge potion 210' has a section with a length of D1P, which extends from to the point when the energy density is approximately constant to a lower point of the crystallization threshold. Similarly, the trailing edge potion 215' has a section with a

20 length of D2P which extends from the point of the crystallization threshold to a higher point of when the energy density is approximately constant.

As shown in Fig. 3, according to an exemplary embodiment of the present invention, the pulses 200 of the line-type beam 164 irradiate all rows of the thin film 175 provided on the semiconductor sample 170 in a controlled manner. For example, the

25 computing arrangement 100 controls the beam source 110 to emit an initial beam so that the beam 164 (either masked by the mask 150 or shaped by the optics of the system) irradiates each row of the semiconductor thin film 175 provided on the sample 170 by translating the stage 180 on which the sample 170 is situated based on the location of the rows of the sample 170, i.e., relative to the direction of the line-type beam 164. In

particular, the computing arrangement 100 has a memory arrangement (not shown) which has stored thereon the location of each of the rows of the semiconductor thin film 175 which are to be irradiated by the beam pulse 200. Therefore, the relative motion of the sample 170 with respect to the line-type beam 164 and the actuation of the beam source

5   110 are performed based on the locations of these rows. Such irradiation of the semiconductor thin film 175 by the line-type beam 164 is continued until all rows of the semiconductor thin film 175 provided on the sample 170 are irradiated by the line-type beam pulses 200 so that they re-solidify and form uniform-grained material areas. According to a preferred embodiment of the present invention, at least the areas in the

10   rows of the semiconductor thin film 175 which are intended to situate microstructures (e.g., TFTs) thereon are preferably irradiated with the top portion 205 of the pulse 200 and fully melted so that these areas (e.g., pixels) can preferably be irradiated once by the convex top portion 205 of the pulse 200 shown in Fig. 4A. It is also possible to irradiate the semiconductor thin film 175 using the top portion 205' of the pulse 200 illustrated in

15   Fig. 4C. In this exemplary embodiment, the top portion 205' has the energy density that is below the complete melting threshold of the thin film 175, thereby only partially melting the thin film 175. Of course, sections of the leading and trailing portions 210, 215 of the embodiment of Fig 4A and the portion 210', 215' of the embodiment shown in Fig. 4C can also irradiate the semiconductor thin film 175 in a similar manner, with

20   certain limitations as shall be described in further detail below.

Fig. 7 illustrates sequential translations of the thin film 175 of the sample 170 with respect to the pulses 200 of the line-type beam 164 shaped by the optics of the system of Fig. 1A and/or patterned by the mask of Fig. 2 according to an exemplary embodiment of the present invention. In this exemplary illustration of the irradiation of

25   the semiconductor thin film 175 provided on the sample 170, the sample 170 is translated in a −Y direction with respect to the direction of the line-type beam 164. When the sample 170 is translated in this manner to a position such that the line-type beam 164 points at a first row 510 of the thin film 175, the beam source 110 is actuated by the computing arrangement 100 so that a first line-type beam pulse 410 irradiates and at least

partially melts, using a beam pulse 200 as depicted in Fig. 4C, or preferably fully melts, using a beam pulse 200 as described in Fig. 4A, one or more portions 511-519 at the first row 510 of the semiconductor thin film 175. The profile and length of the first line-type pulse 410 shown in Fig. 7 substantially corresponds to the profile and length of the pulse

5   200 illustrated in Fig 4A. It is preferable for the width A of the convex top portion 205 of the first pulse 410 to be wide enough to irradiate and completely melt the entire cross-sections of the portions 511-519. These portions can be designated to place certain structures (e.g., TFTs) therein so that they can be used to define the pixels. The resolidified portions which are partially melted would likely possess smaller crystallized-

10   grain regions, but include uniform material therein.

Upon the irradiation and at least partial melting of such portions 511-519 using the top portion 205 of the profile 220' of the embodiment shown in Fig. 4C in the first row 510 of the semiconductor thin film 175 as described above, the melted portions 511-519 resolidify and crystallize so that they have uniform crystal grain growth therein.

15   According to another exemplary embodiment of the present invention and also as mentioned above, the line-type beam 164 may have enough energy density to fully melt (throughout its thickness) the entire row 510 of the thin film 175, or at least the portions 511-519 thereof using the top portion 205 of the profile 220 of the embodiment shown in Fig. 4A. Such fully melted and re-solidified portions of the thin film 175 would have

20   crystal-grains provided therein, which generally do not depend on the sensitivity of the fluence of the line-type beam 164. In this manner, the negative effects of the energy density fluctuations of the of the line-type beam 164 on the uniformity of the resulting TFT devices provided in such re-solidified areas are minimized.

After the first row 510 is irradiated and either partially or fully melted

25   using the line-type pulse 410 as described above, the sample 170 is translated in the −Y direction (via a control of the computing arrangement 100) so that the beam 164 impinges on a second row 520 of the semiconductor thin film 175 provided on the sample 170. As for the first row 510 and upon reaching the second row 520, the beam source 110 is actuated by the computing arrangement 100 to generate a second line-type pulse 420

which irradiates and either at least partially or fully melts one or more sections 521-529
of the second row 520 in substantially the same manner as described above with respect
to the irradiation of the first row 510. This translation of the sample 170 (so that the
impingement of the line-type beam 164 moves from the first row 510 to the second row

5   520 of the semiconductor thin film 175) is executed for a distance D. The distance D can
be also referred to a pixel row periodicity since the translation of the sample 170 via the
distance D is performed for other rows of the sample 170.

It is preferable for this distance D to be pre-assigned such that the trailing
portion 215' of the second line-type pulse 520 does not overlap the leading portion 210' of

10   the first line-type pulse 510. For example, the distance D can be measured from a center
of the top portion 205' of the first pulse 410 to a center of the top portion 205' of the
second pulse 420. It is possible, however, to have certain sections of the trailing portion
215' of the second line-type pulse 520 and of the leading portion 210 of the first line-type
pulse 510 overlap one another. Such portions would preferably possess only the energy

15   densities that are smaller than the crystallization threshold value. Thus, preferably, no
portion of the subsequent pulse 200 of the profile 220' should overlap the section of the
thin film 175 irradiated by the top portion 205' of the preceding pulse 200 of such profile
for the exemplary embodiment of Fig. 4C. This is because the flat top portion 205'
partially melts the thin film 175, and generates grains of uniform size in such irradiated

20   areas.

If any subsequent irradiation on this irradiated section takes place,
uniformity of this area may be compromised. Similarly, if the beam pulse 200 having the
profile 220 of Fig. 4A is utilized, then similar translation distance considerations exist,
except that none of the portions of the profile 220 of the subsequent beam pulse 200

25   should overlap the section of the film sample 175 that was irradiated by the top portion
205 of the previous beam pulse 200. However, contrary to the use of the beam pulse 200
of the embodiment of Fig. 4C, the energy density of the top portion 205 is above the
complete melting threshold, and thus no portion of the subsequent beam pulse should

overlap the completely melted previously section of the thin film 175 so as to avoid non-uniformity of such overlapped section due to the reirradiation thereof.

The sample 170 can then again be translated for the distance D in the same manner as described above with respect to the translation of the sample 164 so as to
5   irradiate the second row 520 of the semiconductor thin film 175. Upon such translation, the line-type beam 164 impinges the third row of the thin film 175, and irradiates and partially melts one or more portions thereof.

Thus, for the embodiment of Fig. 4A, the width B2 of the leading portion 210 (or width B2P) plus the width B1 of the trailing portion 215 (or width B1P) should
10   be smaller than the distance D. In this manner, the leading portion 210 of the second line-type pulse 410 and the trailing portion 215 of the second line-type pulse 420 would not overlap. For the embodiment of Fig. 4C, in a similar manner, the width D2 of the leading portion 210' (or width D2P) and the width D1 of the trailing portion 215' (or width D1P) should both be smaller than the distance D.

15   According to one exemplary embodiment of the present invention, the translation of the sample 170 with respect to the impingement thereof by the beam 164 is performed continuously (e.g., without stopping). The computing arrangement 100 can control the beam source 110 to generate the corresponding pulses 200 based on a predefined frequency. In this manner, it is possible to define the velocity V of the
20   continuous translation of the sample 170 with respect to the impingement of the semiconductor thin film 175 by the line-type pulses 410, 420, so that the respective rows 510, 520 of the thin film 175 are accurately irradiated by the pulses. For example, this velocity V of the translation of the sample 170 can be defined as follows:

$$V = D \times f_{laser}$$

25   where f_{laser} is the frequency of the laser. Thus, if the distance D is 200 μm and the f_{laser} is 300 Hz, the velocity V can be approximately 6 cm/sec, which can be a constant velocity.

According to another embodiment of the present invention, while the sample 170 does not have to be continuously translated with respect to the impingement

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thereof by the beam 164, the actuation of the beam source 110 can be controlled based on a positional signal provided by the translation stage 180. This signal may indicate the position of the sample 170 relative to the position of the impingement thereof by the line-type beam 164. Based on the data associated with such signal, the computing

5   arrangement 100 can direct the actuation of the beam source 110 and the translation to the sample 170 to achieve an effective irradiation of specific portions (e.g., rows) of the semiconductor thin film 170. Thus, the location controlled irradiation of at least portions of the semiconductor thin film 175 can be achieved using a line-type beam 164.

           The description above for the line-type beam 164 has been directed to a

10   Gaussian-shaped beam pulse, the examples of which is illustrated in Figs. 4A and 4C. According to yet another exemplary embodiment of the present invention, it is also possible to utilize a top-hat line-type beam 250, the exemplary profile of which is illustrated in Fig. 8. In particular, this line-type beam 250 has the energy density, which is greater than the complete melting threshold of the semiconductor thin film 175. It

15   should be understood that the energy density of this beam 250 can also be greater than or equal to the crystallization threshold of the semiconductor thin film 175 or above the complete melting threshold. As shown in Fig. 8, the top hat line-type beam 250 generally does not have any leading or trailing portions, and thus the distance D of the translation of the sample 170 does not have to be as great as would be preferable for the Gaussian-

20   type beam. The top-hat line-type beam 250 can be generated using a mask that has a knife edge aperture such that the beam source 110 provides a laser beam , which is then shaped by such a mask.

           Fig. 9A shows an illustration of exemplary first and second irradiated, re-solidified and crystallized portions 511 and 512 of the first row 510 of the semiconductor

25   thin film 175 illustrated in Fig. 7. In particular, Fig. 9A shows that the entire TFT devices 610, 620 can be situated within the respective first and second portions 511, 512 of the first row 510. The first TFT device 610 situated in the first portion 511 of the first row 510 includes a gate 612, a drain 614, a source 616 and an active region 618.

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Similarly, the second TFT device 620 includes a gate 622, a drain 624, a source 626 and
an active region 628.

Fig. 9B shows an another exemplary illustration of the first and second
irradiated, re-solidified and crystallized portions 511 and 512 of the first row 510 of the
5   semiconductor thin film 175, with the respective TFT devices 610', 620' provided
thereon. In this exemplary embodiment, only respective active regions 618', 628' of the
TFT devices 610', 620' are provided within the respective first and second crystallized
portions 511, 512, while other portions of the TFT devices 610', 620' are situated on the
borders of the these portions 511, 512. In particular, the first TFT device 610' includes an
10   active region 618' which entirely situated in the first portion 511 of the first row 510,
while a gate 612', a drain 614' and a source 616' of this TFT device 610' overlap the
borders of the first portion 511. Also, for the second TFT device 610', an active region
628' thereof is entirely situated within the respective second portion 512 of the first row
510, while a gate 622', a drain 624' and a source 626' of the second TFT device 620' are
15   provided directly on the borders of such second portion 512. It should be understood that
any one of the gate 612, 612', 622, 622', drain 614, 614', 624, 624' and source 616, 616',
626, 626' can be provided on the first and second areas 511, 512 and the border regions
thereof.

It should be understood that the above description is equally applicable for
20   all portions 511-519, 521-529, etc. of the semiconductor thin film 175. In addition, the
above placement of the active regions 618, 628, 618', 628' within the portions 511-19,
521-529, etc. is possible due to the uniformity achieved using the exemplary system and
process according to the present invention described herein.

Fig. 10 shows another exemplary illustration of sequential movements of
25   the sample 170 by the translation stage 180 with respect to the impingement of the pulses
of the line-type beam shaped by the optics of the system of Fig. 1A or patterned by the
mask of Fig. 2. In this exemplary embodiment, the relative translation of the sample 170
with respect to the impingement by the line-type pulses 410, 420 are substantially similar
to the relative translation of the sample described above with reference to Fig. 3.

However, the length of the line-type beam 164 in this embodiment is approximately half
the length L of the embodiment of the line-type beam 164 of Fig. 3. For example, the
profile of the line-type beam 164 shown in Fig. 10 can be 15 cm, irradiating the sample
170 which has a width which is smaller than 30 cm. Accordingly, using such beam

5   length, the entire sample 170 is irradiated in two passes. In particular, one half of the
sample 170 is irradiated in the manner described above with reference to Fig. 7 by, e.g.,
irradiating such half section of the sample 170 while translating the sample 170 in the -Y
direction. When the impingement of the line-type beam 164 completes the irradiation of
the entire half section of the sample 170 (i.e., reaches an opposite edge from which the

10   irradiation began), the sample 170 is translated in the –X direction, and second half
section of the sample 170 is irradiated while translating the sample 175 in the +Y
direction. Thus, the entire sample 170 can be irradiated by the line-type beam 164 in two
passes. It is also within the scope of the present invention to use the line-type beams
which have shorter lengths, so that a larger number of passes are performed to completely

15   process the sample 170.

          Fig. 11 shows a flow diagram representing an exemplary processing
procedure of the present invention under at least partial control of the
computing/processing arrangement 100 of Fig. 1A using the exemplary techniques of the
present invention provided in Figs. 7 and 10. In step 1000, the hardware components of

20   the system of Fig. 1A, such as the beam source 110, the energy beam modulator 120, and
the beam attenuator and shutter 130 are first initialized at least in part by the computing
arrangement 100. The sample 170 is loaded onto the sample translation stage 180 in step
1005. It should be noted that such loading may be performed either manually or
automatically using known sample loading apparatus under the control of the computing

25   arrangement 100. Next, the sample translation stage 180 is moved, preferably under the
control of the computing arrangement 100, to an initial position in step 1010.

          Various other optical components of the system are adjusted and/or
aligned either manually or under the control of the computing arrangement 100 for a
proper focus and alignment in step 1015, if necessary. In step 1020, the irradiation/laser

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beam 111 is stabilized at a predetermined pulse energy level, pulse duration and repetition rate. In step 1024, it is preferably determined whether each beam pulse 164 has sufficient energy to at least partially melt (and preferably fully melt) the irradiated portions of the semiconductor thin film 175 without overheating. If that is not the case,

5　the attenuation of the beam 111 is adjusted by the beams source 110 under the control of the computing arrangement 100 in step 1025, and step 1024 is executed again to determine if the there is sufficient energy to at least partially melt the portions of the semiconductor thin film 175.

　　　　　In step 1027, the sample 170 is positioned to point the pulse 410 of the

10　line-type beam 164 to impinge the first row 510 of the semiconductor thin film 175. Then, in step 1030, the respective row of the semiconductor thin film 175 is irradiated and at least partially melted using a masked intensity pattern (e.g., using the mask 150 illustrated in Fig. 2). Thereafter, the irradiated row (and/or portions thereof) of the semiconductor thin film 175 are allowed to solidify and crystallize. In step 1045, it is

15　determined whether there are any more rows of the sample 170 that is to be subjected to the irradiation, i.e., whether the irradiation, melting and resolidification of the semiconductor thin film 175 has been completed. If not, in step 1050, the sample 175 is translated so that the line-type beam impinges the next row of the sample 170, and the processing is returned to step 1030 for irradiating of the current row of the semiconductor

20　thin film 175. However, if in step 1045, it is determined that the irradiation and crystallization of the sample 170 is completed, and the hardware components and the beam 111 of the system shown in Fig. 1A can be shut off, and the process is terminated in step 1055.

　　　　　Using the system and process according to the present invention, it is

25　possible to obtain a significantly greater crystallization rate over that of the conventional systems and processes. This crystallization rate is provided as follows:

　　　　　Crystallization Rate = Beam Length × Frequency of Laser × Pitch

For example, the crystallization rate effectuated by conventional system and process is:

$$50 \text{ cm} \times 20 \text{ } \mu\text{m} \times 300 \text{ Hz} = 30 \text{ cm}^2/\text{sec (for a 20 shot process)}$$

In contrast, the crystallization rate afforded by the system and process according to the present invention is:

$$50 \text{ cm} \times 300 \text{ } \mu\text{m} \times 300 \text{ Hz} = 450 \text{ cm}^2/\text{sec.}$$

5   The foregoing merely illustrates the principles of the invention. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. For example, while the above embodiment has been described with respect to at least partial or full solidification and crystallization of the semiconductor thin film, it may apply to other materials processing

10   techniques, such as micro-machining, photo-ablation, and micro-patterning techniques, including those described in International patent application no. PCT/US01/12799 and U.S. patent application serial nos. 09/390,535, 09/390,537 and 09/526,585, the entire disclosures of which are incorporated herein by reference. The various mask patterns and intensity beam patterns described in the above-referenced patent application can also be

15   utilized with the process and system of the present invention so long as a line-type beam pulses are generated. It will thus be appreciated that those skilled in the art will be able to devise numerous systems and methods which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the present invention.

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What Is Claimed Is:

1.   A method for processing at least one section of a thin film sample on a substrate, comprising the steps of:

        (a)   controlling an irradiation beam generator to emit successive irradiation beam pulses at a predetermined repetition rate;

        (b)   shaping each of the irradiation beam pulses to define at least one line-type beam pulse, wherein a profile of each of the line-type beam pulses includes a top portion, a leading portion and a trailing portion, the at least one line-type beam pulse being provided for impinging the film sample;

        (c)   irradiating a first portion of the film sample with at least the top portion of a first one of the line-type beam pulses, to at least partially melt the first portion, the irradiated first portion being allowed to resolidify and crystallize to form approximately uniform areas therein, and

        (d)   after step (c), irradiating a second portion of the film sample with at least the top portion of a second one of the line-type beam pulses to at least partially melt the second portion, the irradiated second portion being allowed to resolidify and crystallize to form approximately uniform areas therein,

        wherein an emission of the second one of the line-type beam pulses immediately follows an emission of the first one of the line-type beam pulses, wherein at least one section of the first portion of the film sample is prevented from being irradiated by the trailing portion of the second one of the line-type beam pulses.

2.   The method according to claim 1, wherein the top portion of each of the line-type beam pulses has an energy density which is above a complete melting threshold.

3.   The method according to claim 1, wherein the top portion of each of the line-type beam pulses has an energy density which is below a complete melting threshold.

4.   The method according to claim 1, wherein each of the leading and trailing portions of the first one of the line-type beam pulses irradiates a part of the first portion, and wherein each of the leading and trailing portions of the second one of the line-type beam pulses irradiates a part of the second portion.

5.   The method according to claim 1,

        wherein each of leading and trailing portions of the first and second ones of the line-type beam pulses has first and second sections,

        wherein each of the first sections of the leading and trailing portions of the first and second ones of the line-type beam pulses has an energy density which is sufficient to at least partially melt at least one of the respective first portion and the respective second portion, and

        wherein each of the second sections of the leading and trailing portions of the first and second ones of the line-type beam pulses has an energy density lower than a threshold level which is sufficient to at least partially melt at least one of the respective first portion and the respective second portion.

6.   The method according to claim 1, wherein step (d) is performed after step (c) is completed and after the film sample is translated for a particular distance with respect to an impingement by the beam pulses of the first portion.

7.   The method according to claim 6, wherein the leading portion of the first one of the line-type beam pulses has a first length, wherein the top portion of the first one of the line-type pulses has a second length, and the trailing portion of the second one of the line-type beam pulses has a third length, and wherein the particular distance is greater than the sum of the first, second and third lengths.

8.   The method according to claim 1, wherein a section of the leading portion of the first one of the line-type beam pulses that has an energy density that is between a complete melting threshold and a crystallization threshold and has a first length, wherein

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the top portion of the first one of the line-type pulses has an energy density that is above the complete melting threshold and has a second length, and the trailing portion of the second one of the line-type beam pulses has energy density that is below the complete melting threshold and has a third length, and wherein the particular distance at least a larger of the sum of the first and second lengths and the sum of the second and third lengths.

9.   The method according to claim 1, wherein the beam pulse has a Gaussian shape.

10.   The method according to claim 1, wherein the first portion of the film sample is irradiated by the top portion of the first one of the line-type beam pulses, wherein the second portion of the film sample is irradiated by the top portion of the second one of the line-type beam pulses, wherein the top portion of each of the first and second ones of the line-type beam pulses has an approximately constant energy density, and wherein the first and second irradiated areas are partially melted by the respective first and second ones of the line-type beam pulses.

11.   The method according to claim 1, wherein no portion of the second one of the beam pulses irradiates any section of the first irradiated and resolidified area.

12.   The method according to claim 1, wherein the at least one section of the first portion of the film sample that is prevented from being irradiated by the trailing portion of the second one of the line-type beam pulses includes an active region.

13.   The method according to claim 1, wherein the first and second portions of the film sample include active regions of a thin film device.

14.   The method according to claim 1, wherein the irradiation beam pulses are shaped by a mask to define the line-type beam pulses.

15.   The method according to claim 1, further comprising the step of:

        (g)   after step (c) and before step (d), translating the film sample for a
particular distance with respect to an impingement by the beam pulses in a periodic
manner and based on a frequency of the irradiation of the irradiation beam generator.

16.   The method according to claim 1, wherein the first and second portions of the
film sample include pixel areas.

17.   The method according to claim 1, wherein the first and second portions include
areas which are configured to situate thereon an active region of at least one thin-film
transistor "TFT" device.

18.   A method for processing at least one section of a thin film sample on a substrate,
comprising the steps of:

        (a)   controlling an irradiation beam generator to emit successive irradiation
beam pulses at a predetermined repetition rate;

        (b)   shaping each of the irradiation beam pulses to define at least one line-type
beam pulse, wherein a profile of each of the line-type beam pulses includes a top portion,
a leading portion and a trailing portion, the at least one line-type beam pulse being
provided for impinging the film sample;

        (c)   irradiating a first portion of the film sample with at least the top portion of
a first one of the line-type beam pulses, to at least partially melt the first portion, the
irradiated first portion being allowed to resolidify and crystallize to form approximately
uniform areas therein, and

        (d)   after step (c), irradiating a second portion of the film sample with at least
the top portion of a second one of the line-type beam pulses to at least partially melt the
second portion, the irradiated second portion being allowed to resolidify and crystallize to
form approximately uniform areas therein,

        wherein an emission of the second one of the line-type beam pulses immediately
follows an emission of the first one of the line-type beam pulses, wherein at least one

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section of the first portion of the film sample is prevented from being irradiated by the
trailing portion of the second one of the line-type beam pulses

(e)   receiving data associated with locations on the film sample to be
irradiated; and

(f)   after step (c) and before step (d), translating the film sample for a
particular distance with respect to an impingement by the beam pulses based on the
received data.

19.   The method according to claim 18, wherein the top portion of each of the line-
type beam pulses has an energy density which is above a complete melting threshold.

20.   The method according to claim 18, wherein the top portion of each of the line-
type beam pulses has an energy density which is below a complete melting threshold.

21.   A system for processing at least one section of a thin film sample on a substrate,
comprising:

a processing arrangement, which when executing a computer program, is
configured to perform the following steps:

(a)   controlling an irradiation beam generator to emit successive irradiation
beam pulses at a predetermined repetition rate,

(b)   controlling a shaping of each of the irradiation beam pulses to define at
least one line-type beam pulse, wherein a profile of each of the line-type
beam pulses includes a top portion, a leading portion and a trailing
portion, the at least one line-type beam pulse being provided for impinging
the film sample;

(c)   controlling an irradiation of a first portion of the film sample with at least
the top portion of a first one of the line-type beam pulses, to at least
partially melt the first portion, the irradiated first portion being allowed to
resolidify and crystallize to form approximately uniform areas therein, and

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(d)   after step (c), controlling an irradiation of a second portion of the film
       sample with at least the top portion of a second one of the line-type beam
       pulses to at least partially melt the second portion, the irradiated second
       portion being allowed to resolidify and crystallize to form approximately
       uniform areas therein,

wherein the processing arrangement controls an emission of the second one of the
line-type beam pulses to immediately follow an emission of the first one of the line-type
beam pulses, wherein at least one section of the first portion of the film sample is
prevented from being irradiated by the trailing portion of the second one of the line-type
beam pulses.

22.   The method according to claim 21, wherein the top portion of each of the line-
type beam pulses has an energy density which is above a complete melting threshold.

23.   The method according to claim 21, wherein the top portion of each of the line-
type beam pulses has an energy density which is below a complete melting threshold.

24.   The system according to claim 21, wherein the processing arrangement, when
executing the compute program, controls each of the leading and trailing portions of the
first one of the line-type beam pulses to irradiate a part of the first portion, and wherein
each of the leading and trailing portions of the second one of the line-type beam pulses
irradiates a part of the second portion.

25.   The system according to claim 21,
wherein each of leading and trailing portions of the first and second ones of the
line-type beam pulses has first and second sections,
wherein each of the first sections of the leading and trailing portions of the first
and second ones of the line-type beam pulses has an energy density which is sufficient to
at least partially melt at least one of the respective first portion and the respective second
portion, and

wherein each of the second sections of the leading and trailing portions of the first and second ones of the line-type beam pulses has an energy density lower than a threshold level which is sufficient to at least partially melt at least one of the respective first portion and the respective second portion.

26.   The system according to claim 21, wherein the processing arrangement, when executing the computer program, performs step (d) after step (c) is completed and after the film sample is translated for a particular distance with respect to an impingement by the beam pulses of the first portion.

27.   The system according to claim 27, wherein the leading portion of the first one of the line-type beam pulses has a first length, wherein the top hat portion of the first one of the line-type pulses has a second length, and the trailing portion of the second one of the line-type beam pulses has a third length, and wherein the particular distance is greater than the sum of the first, second and third lengths.

28.   The system according to claim 21, wherein a section of the leading portion of the first one of the line-type beam pulses that has energy density that is between a complete melting threshold and a crystallization threshold and has a first length, wherein the top portion of the first one of the line-type pulses has energy density that is above the complete melting threshold and has a second length, and the trailing portion of the second one of the line-type beam pulses has energy density that is below the complete melting threshold and has a third length, and wherein the particular distance at least a larger of the sum of the first and second lengths and the sum of the second and third lengths.

29.   The system according to claim 21, wherein the beam pulse has a Gaussian shape.

30.   The system according to claim 21, wherein the first portion of the film sample is irradiated by the top portion of the first one of the line-type beam pulses, wherein the second portion of the film sample is irradiated by the top portion of the second one of the

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line-type beam pulses, wherein the top portion of each of the first and second ones of the line-type beam pulses has an approximately constant energy density, and wherein the first and second irradiated areas are partially melted by the respective first and second ones of the line-type beam pulses, wherein the top portion of each of the first and second ones of the line-type beam pulses has an approximately constant energy density, and wherein the first and second irradiated areas are partially melted by the respective first and second ones of the line-type beam pulses.

31.   The system according to claim 21, wherein no portion of the second one of the beam pulses irradiates any section of the first irradiated and resolidified area.

32.   The system according to claim 21, wherein the at least one section of the first portion of the film sample that is prevented from being irradiated by the trailing portion of the second one of the line-type beam pulses includes an active region.

33.   The system according to claim 21, wherein the first and second portions of the film sample include active regions of a thin film device.

34.   The system according to claim 21, wherein the irradiation beam pulses are shaped by a mask to define the line-type beam pulses.

35.   The system according to claim 21 wherein the processing arrangement, when executing the computer program, is further configured to perform the following steps:
        (g)   after step (c) and before step (d), translating the film sample for a
                particular distance with respect to an impingement by the beam pulses in
                a periodic manner and based on a frequency of the irradiation of the
                irradiation beam generator.

36.   The system according to claim 21, wherein the first and second portions of the film sample include pixel areas.

37.   The system according to claim 21, wherein the first and second portions include areas which are configured to situate thereon an active region of at least one thin-film transistor "TFT" device.

38.   A system for processing at least one section of a thin film sample on a substrate, comprising:

a processing arrangement, which when executing a computer program, is configured to perform the following steps:

(a)   controlling an irradiation beam generator to emit successive irradiation beam pulses at a predetermined repetition rate,

(b)   controlling a shaping of each of the irradiation beam pulses to define at least one line-type beam pulse, wherein a profile of each of the line-type beam pulses includes a top portion, a leading portion and a trailing portion, the at least one line-type beam pulse being provided for impinging the film sample,

(c)   controlling an irradiation of a first portion of the film sample with at least the top portion of a first one of the line-type beam pulses, to at least partially melt the first portion, the irradiated first portion being allowed to resolidify and crystallize to form approximately uniform areas therein,

(d)   after step (c), controlling an irradiation of a second portion of the film sample with at least the top portion of a second one of the line-type beam pulses to at least partially melt the second portion, the irradiated second portion being allowed to resolidify and crystallize to form approximately uniform areas therein, wherein the processing arrangement controls an emission of the second one of the line-type beam pulses to immediately follow an emission of the first one of the line-type beam pulses, wherein at least one section of the first portion of the film sample is prevented from being irradiated by the trailing portion of the second one of the line-type beam pulses

(e)   receiving data associated with locations on the film sample to be
        irradiated, and

(f)   after step (c) and before step (d), translating the film sample for a
        particular distance with respect to an impingement by the beam pulses
        based on the received data.

39.   A section of a thin film sample provided on a substrate, comprising:

        a first irradiated and crystallized portion; and

        a second irradiated and crystallized portion which does not overlap the first
portion,

        -    wherein each of the first and second portions are irradiated by line-type
             beam pulses, wherein a profile of each of the line-type beam pulses
             includes a top portion, a leading portion and a trailing portion, the at least
             one line-type beam pulse being provided for impinging the film sample,
             the at least one line-type beam pulses being provided for impinging the
             film sample,

        -    wherein the first portion is irradiated with at least the top portion of a first
             one of the line-type beam pulses, to at least partially melt the first portion,
             the irradiated first portion being allowed to resolidify and crystallize to
             form approximately uniform areas therein,

        -    wherein after the irradiation of the first portion, the second portion is
             irradiated with at least the top portion of a second one of the line-type
             beam pulses to at least partially melt the second portion, the irradiated
             second portion being allowed to resolidify and crystallize to form an
             approximately uniform area therein,

        -    wherein an emission of the second one of the line-type beam pulses
             immediately follows an emission of the first one of the line-type beam
             pulses, and

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—   wherein a section of the first portion impacted by /–ε top portion of the
first one of the line-type beam pulses is prevented from being irradiated by
trailing portion of the second one of the line-type beam pulses.

5   40.   The system according to claim 38, wherein the top portion of each of the line-type
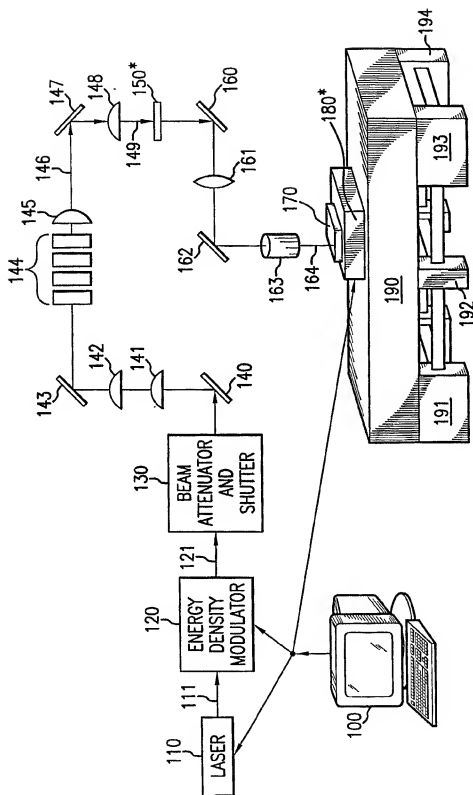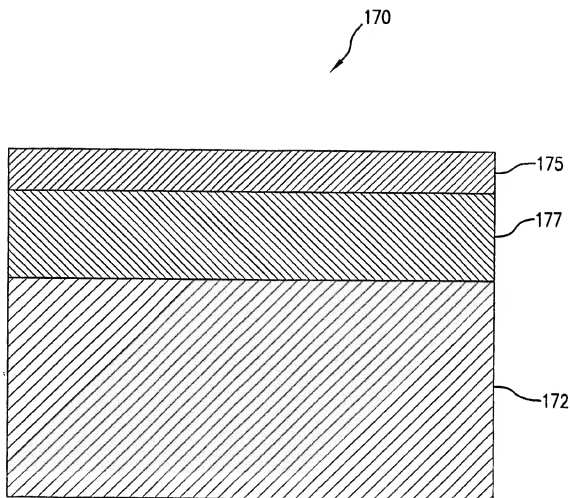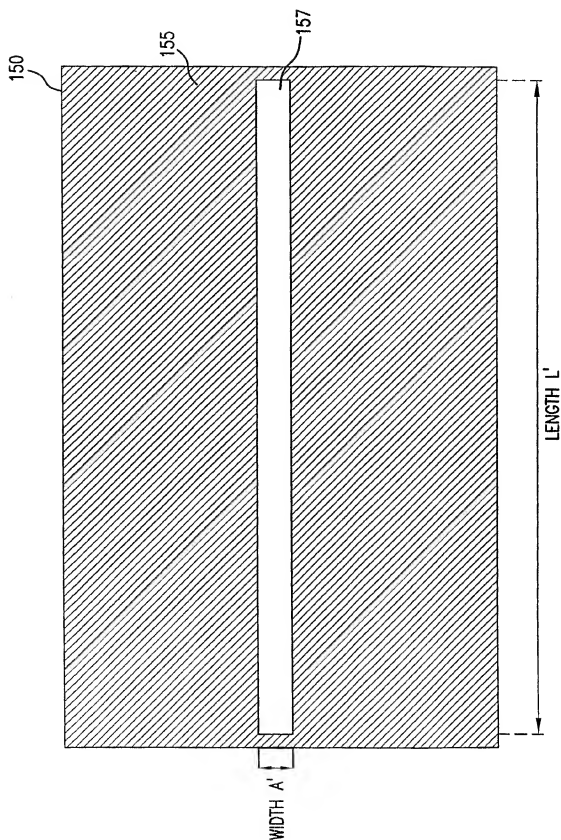beam pulses has an energy density which is above a complete melting threshold.

41.   The system according to claim 38, wherein the top portion of each of the line-type
beam pulses has an energy density which is below a complete melting threshold.

FIG.1A

FIG.1B

FIG.2

SUBSTITUTE SHEET (RULE 26)

FIG.3

FIG.4A

FIG.4B

FIG.4C

FIG.5
PRIOR ART

FIG.6A

FIG.6B

FIG.6C

FIG.6D

FIG.7

FIG.8

FIG.9A

FIG.9B

FIG.10

FIG. 11

START → INITIALIZE HARDWARE — 1000

↓

LOAD SAMPLE — 1005

↓

MOVE STAGE TO INITIAL POSITION — 1010

↓

ADJUST FOCUS AND ALIGNMENT OF OPTICAL SYSTEM, IF NECESSARY — 1015

↓

STABILIZE LASER AT DESIRED RADIATION BEAM PULSE ENERGY LEVEL AND REPETITION RATE — 1020

↓

1024 — EACH PULSE HAS SUFFICIENT ENERGY TO AT LEAST PARTIALLY MELT IRRADIATED PORTION OF SEMICONDUCTOR THIN FILM SO IT CRYSTALLIZES?

NO → ADJUST ATTENUATION — 1025

YES ↓

POSITION SAMPLE TO POINT THE BEAM TO IMPINGE A FIRST ROW OF SAMPLE — 1027

↓

IRRADIATE SAMPLE WITH FIRST RADIATION BEAM PULSE HAVING LINE-SHAPED INTENSITY PATTERN OR LINE-SHAPED BEAM — 1030

↓

ANY MORE ROWS OF SAMPLE TO BE IRRADIATED FOR PROCESSING? — 1045

NO → TRANSLATE SAMPLE SO THAT THE BEAM IS POINTED TO THE NEXT ROW FOR CRYSTALLIZATION PROCESSING — 1050

YES → SHUT OFF RADIATION BEAM AND HARDWARE — 1055

↓

STOP